FY2009 Annual Report
National Program 203 – Air Quality

Introduction

'Air quality' refers to the combination of the physical, chemical and biological constituents of air masses in the lower atmosphere with which humans, animals, plants, lands, and water bodies of the earth interact. These constituents may take the form of solids (such as suspended particulates), gases (such as oxygen and nitrogen), and liquids (such as water droplets or vapor). We use the term 'air quality' to refer to the state of air with reference to its ability to maintain a high level of human health as the first priority, with secondary priorities associated with animal and environmental health. Air quality affects and is affected by human, plant, and animal activities, including life functions. The sweep of winds and the exchange of gases, liquids, and solids between air masses and land and water surfaces affect air quality.

Air quality has both local and global contexts. Odorous compounds emitted by a localized source, for example, may be readily detectable by humans within a relatively short distance as the compounds that are identified by the nose become dispersed. Additionally, particulates of very small size may enter intercontinental air streams and travel around the globe sometimes for years, as is exemplified by colorful sunsets that follow periods of intense volcanic activity.

Agriculture is a necessary human activity that interacts with air, benefitting from good quality air and contributing air pollutants. Agriculture needs air that is free of excessive amounts of such constituents as ozone, dust, suspended pesticides, and odors. However, agriculture may also contribute these substances to the air in quantities that are offensive or even threatening to the human and environmental health of downwind areas.

The Agricultural Research Service (ARS) developed an Air Quality National Program on the premise that many problems associated with air quality degradation by agriculture can be reduced or eliminated through research to understand polluting processes and application of that understanding to develop solutions. An additional premise underlying the National Program is that air pollution impacts on agriculture can be resolved through research and development.

Component 1: Particulate Emissions.

The objective of this research component is to develop agricultural technologies and practices that minimize contamination of the air by particulates generated during the production and processing of food and fiber, and provide science-based technology for sound policy and regulatory decisions.

Selected Accomplishments

Adoption of an Improved Wind Erosion Prediction System (WEPS). The Wind Erosion Prediction System (WEPS) model, developed by ARS scientists in Manhattan, KS, to calculate wind erosion of soils, was significantly improved to account for the sparseness of wind data throughout the western US. A lack of localized wind speed data creates significant errors when calculating wind energy needed for wind erosion predictions. To overcome this limitation, an algorithm was developed to interpolate wind data between measurement locations using geospatial weighted averaging. The algorithm is fully operational and integrated with WEPS. This interpolation will allow a wider use of WEPS in areas of the US where there are no wind stations, especially in the intermountain region of the western US. Implementation of WEPS in 3000+ NRCS field offices nation-wide will begin during 2010 as a tool to develop land management plans for reduced soil loss and degradation of air quality from wind erosion of soil.

Performance of the Wind Erosion Prediction System (WEPS) Assessed for Wind Storms of Pacific Northwest Columbia Basin. The Wind Erosion Prediction System (WEPS) is the latest model being developed to evaluate wind erosion from agricultural lands throughout the United States. There is little information, however, about the performance of WEPS to predict how much dust is blown away from agricultural fields during wind storms. These wind storms are particularly common in dryland farming regions of the Pacific Northwest Columbia Plateau, and in addition to contributing to the loss of valuable topsoil, threaten the health of people and animals that breathe the dusty air. ARS scientists at Pullman, WA have measured the amount of dust carried away by winds and compared this to the amount predicted by WEPS. For many cases, the measured and predicted amounts of dust blown away from fields was different, and indicating the need for modifications to WEPS to enable better forecasts of dust storms throughout the Columbia Plateau. When WEPS is modified to enable accurate predictions of dust blown away from fields of the Columbia Plateau, farmers and land managers within this region will be able to run simulations of wind erosion for different management strategies and choose production practices with reduced wind erosion. This will lead to reduced loss of topsoil and improved air quality for the Pacific Northwest Columbia Plateau.

Component 2: Ammonia and Ammonium.

The objective of the Ammonia and Ammonium Research Component is to develop systems to reduce ammonia emissions from cropping and animal production systems while improving productivity.

Most of this research is performed under the NP206 Manure and Byproduct Utilization Research Program. During 2008 NP206 conducted its five-year retrospective review and held its customer workshop to begin developing its research plan for the next five years.

The NP206 Program Retrospective Report is posted to the web and contains summaries of ammonia emissions research conducted over the past 5 years by ARS.

Selected Accomplishments

Ammonia Emissions from Wisconsin Dairy Farms Lower Than Expected. Ammonia in the atmosphere is an environmental concern because it is the primary alkaline gas that neutralizes acidic atmospheric gases produced from the combustion of fossil fuels. This reaction produces aerosols that are components of atmospheric haze, and are a potential human health hazard. Ammonia is emitted from dairy farms, but there has been little data quantifying the amount emitted, or whether this amount varies from season to season or with different dairy management options. Studies were conducted by the ARS Dairy Forage Research Center in Madison, Wisconsin to obtain representative and accurate ammonia emissions data from large dairy farms in Wisconsin. Ammonia concentrations and climatic measurements were made on three dairy farms (>800 cows) during the winter, summer, and autumn. During autumn and summer, whole-farm emissions were significantly greater than observed during winter, with about two-thirds of the total emissions originating from the waste management systems. The mean whole-farm winter, autumn, and summer ammonia emissions were 1.5, 7.5, and 13.7% of feed nitrogen inputs, respectively. Average annual emissions were similar between the three farms at 7.0, 7.5, and 8.4% of input feed nitrogen emitted as ammonia, with an annual average for all three farms of 7.6 ± 1.5%. Based on these data, ammonia emissions from Wisconsin dairy farms are considerably smaller than previously expected, and significantly smaller than measured emissions from other types of animal-feeding operations. These studies provide accurate, scientifically based information about dairy farming's impact on the environment in terms of ammonia emissions that will be part of the decision-making criteria for future policy decisions on dairy farming and its relationship to air quality.

Worksheet for Estimating Feedlot Ammonia Emissions for EPCRA. A recent ruling by the Environmental Protection Agency (EPA) required cattle feeders to report ammonia emissions under the Emergency Planning and Community Right-to-Know Act (EPCRA). At the request of the Texas Cattle Feeders Association, ARS researchers at the Conservation and Production Research Laboratory, Bushland, Texas, led a group of scientists from ARS and Texas AgriLife Research that compiled the state-of-the-science of ammonia emissions from cattle feedyards. This report was used by the National Cattlemen's Beef Association (NCBA) to develop a worksheet to estimate feedlot ammonia emissions that could be used to meet EPCRA reporting requirements. The worksheet was delivered online, in newsletters and through an online webinar to NCBA affiliates, which reached about 85% of the cattle feeding industry and allowed the cattle industry to meet the regulatory reporting requirements despite a very short deadline.

Effects of Distiller's Grains on Ammonia Losses from Commercial Feedyards. Diversion of corn grain to ethanol production more than doubled from 2003 to 2008, making a readily available cattle feed byproduct called distiller's grains. However, distiller's grains in cattle feed increase the nitrogen content of rations and increase the potential for the loss of ammonia to the atmosphere from cattle manure. Scientists at the

ARS Conservation and Production Research Laboratory, Bushland, Texas, used a comprehensive database of ammonia emissions collected at a feedyard that fed distiller's grains, and a feedyard that fed only corn-based rations, to investigate the effect of distiller's grains on ammonia emissions. Prior to the availability of distiller's grains, there was no difference in either dietary crude protein concentrations or ammonia emissions between the two feedyards. Feeding distiller's grains significantly increased crude protein content of manure from 13% to 19%, and significantly increased mean monthly ammonia emissions from 44% to 144%. Feeding distiller's grains utilizes a valuable byproduct increasingly available as corn is diverted to ethanol production, but the increased crude protein in the diet results in increased ammonia emissions. Thus, if feeding distiller's grains to is to continue, additional measures must be taken to reduce ammonia emissions from cattle feedyards.

Component 3: Malodorous Compounds.

The objective of the malodorous compounds component research is to develop practices and technologies for animal production systems that minimize gaseous and particulate emissions and human health impacts and provide information for science-based policy and regulation decisions. Most of this research is also performed under the NP206 Manure and Byproduct Utilization Research Program.

Selected Accomplishments

Identification of key odorants from livestock production facilities. Despite years of research, there is no agreement on a definitive list of key chemicals responsible for the "odor" generated from livestock production facilities. Using gas chromatography-olfactometry, researchers at the ARS National Laboratory for Agriculture and the Environment in Ames, IA identified key elements of odors produced from swine and beef production facilities, and found that the chemical nature of odor changed with distance. At the source, key odorants included volatile fatty acids and phenol and indole compounds; 400 meters downwind, key odorants included only phenol and indole compounds, with a minor component being volatile fatty acids; while 3200 meters downwind, key odorants were dominated by indoles, with phenols representing only a minor component. Understanding the chemical nature of livestock production facility odors is the first step towards developing strategies to mitigate this unpleasant component of livestock production.

Second Generation Environmentally Superior Technology for the Remediation of Odor from Livestock Waste Developed. Emissions of odorous compounds from confined animal feeding operations are a source of complaints, and may also have adverse environmental impacts. ARS Scientists from Bowling Green, KY, and Florence, SC, studied reductions of odorous compounds effected by a second generation wastewater treatment plant during three cycles of pig rearing. The wastewater treatment system consisted of three modules: solids separation, biological nitrogen removal, and phosphorus recovery/wastewater disinfection. While over 90% of the wastewater solids

were removed in the first stage of treatment, little reduction in the odor-causing compounds occurred, indicating that these substances largely remained within the liquid waste stream. The greatest improvements in wastewater quality occurred in the nitrogen treatment module where there was a 90% reduction in compounds responsible for odors as compared to the raw flushed manure. The system consistently achieved high performance standards, even during the first cycle of livestock production while system performance was being optimized. These findings showed that the combination of two simple processes into a practical treatment system can be very effective in reducing odorous compounds from livestock wastewater.

Component 4: Ozone Impacts.

The objectives of the ozone impacts research component are to identify ozone-tolerant crop species and varieties, response mechanisms to select or develop tolerant varieties, production methods that minimize ozone-induced limitations on crop production, and quality in general to develop the science-based information required for sound policy and regulatory decisions.

Selected Accomplishments

Ozone-tolerant soybean ancestors identified. Developing ozone tolerant plants is one approach to alleviating the adverse effects of air pollution on crops. Results from prior year greenhouse screening of soybean ancestors for ozone-induced foliar injury by ARS researchers in Raleigh, NC were combined with pedigree analysis techniques to predict the ozone resistance of 247 publically-released soybean cultivars. Predicted injury scores suggested that cultivars from the Midwest may be more sensitive to ozone-induced foliar injury than Southern cultivars. Ancestors with the greatest ozone resistance were not major contributors to current US cultivars, and thus represent sources for ozone tolerance genes for integration into new cultivars.

The ozone component of global change: effects on agricultural and horticultural plant yield, product quality and interactions with invasive species. The performance and quality of agricultural and horticultural plants in many regions of the world are adversely affected by current and anticipated concentrations of ground-level ozone. ARS researchers in Raleigh, NC examined recent data showing that current ambient ozone concentrations in the eastern U.S. cause substantially different levels of damage to otherwise similar snap bean cultivars. It was further demonstrated that ozone can have undesirable effects on yield quality that directly affect seed and fruit chemistry, as well as forage crop nutritional value with its consequences for animal production. Ozone can also alter the efficacy of herbicides, and improve the ability of some invasive species to compete with indigenous plants and crops. Plant breeding activities that incorporate influences of ozone pollution into selection strategies along with altered production practices and abandonment of sensitive cultivars, will be increasingly necessary to achieve sustainable production with changing atmospheric composition.

Component 5: Pesticides and Other Synthetic Organic Compounds.

The objective of this research is to develop agricultural production systems that minimize unwanted emission and transport of pesticides. Research on alternatives to methyl bromide is conducted under National Program NP308.

Selected Accomplishments

Herbicide Volatilization is Primarily Determined by Surface Soil Moisture. Decision support systems for herbicide applications are needed to minimize herbicide losses to the environment via volatilization. Unfortunately, current physically-based models fail to accurately estimate or predict such losses. A 5 year field-scale pesticide volatilization experiment was conducted to determine if hydrologically active regions with identical soil texture and management affect pesticide losses to the atmospheric. Results showed that hydrologically active zones, defined with the Soil Moisture Response Index (SMRI), had higher surface soil moisture, primarily due to subsurface flow pathways, and that the wetter zones generated considerably higher pesticide volatilization losses: a doubling of surface soil moisture was shown to double metolachlor volatilization, while a 30% increase of soil organic content had no effect. Although organic matter and soil texture were thought to determine pesticide volatilization at the field-scale, these investigations demonstrate that pesticide volatilization is governed primarily by surface soil moisture, and explain why physically based models have in the past, failed to accurately estimate volatilization losses. This multi-year investigation elevates the importance of surface soil moisture to pesticide volatilization, such that future models will have to account for surface soil moisture to be accurate.

Atmospheric Transport of Pesticides Dependent on More than Just Distance from the Source. Atmospheric transport of pesticides to the Sierra Nevada Mountains of California has been implicated as a factor adversely affecting biological resources such as amphibians and fish. Studies were conducted to examine pesticide distribution in the high-elevations of the Sierra Nevadas, and the relationship of concentration to distance from sources in the adjacent, high-agricultural use, San Joaquin Valley. Although most mountain sites received the same compounds, the concentrations of some pesticides were very much related to distance from the Valley, while in other cases no relationship with distance was observed. These results suggest that while atmospheric transport processes are important, other on-site characteristics and/or processes need to be accounted for to explain observed differences in chemical concentrations among high-elevation sites. Identification and quantification of these other factors will facilitate the development of mitigation strategies to help decrease the unintended release and transport of pesticides to the atmosphere.

Future Activities

During 2010, the ARS Air Quality Research Program will be integrated with the NP 202 Soils Research Program and the NP 204 Global Change Research Program into the new NP 212 Climate Change, Soils and Emissions Research Program. New air quality

research project plans will be developed and reviewed by outside panels convened by the ARS Office of Scientific Quality Review. These project plans were developed with insights gained from a National Program workshop held during May 2008. During the workshop, ARS scientists met with stakeholders and collaborators to determine research priorities for the next five years.

An Action Plan for the NP 212 Climate Change, Soils and Emissions Research Program was developed during the final months of 2008, and serves as a framework for the research to be conducted by NP 212 scientists.